Introduction to the course

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The teacher

Course instructor: Manel Martínez-Ramón

- Telecommunications engineer (track in Electronics), UPC, Spain, 1996. PhD in Machine learning in communications (UCIIIM, Spain, 1999).
- Professor, ECE department, the University of New Mexico
- King Felipe VI endowed chair.
- Expert in machine learning: Active research in ML since 1998.
- Taught about 30 different classes in Machine Learning, Probability, Signal Processing, Communications, Electronics, Electromagnetics and others.

Machine Learning Map

Course objectives:

C1. Learn the fundamentals of machine learning from a theoretical point of view.

C2. Apply machine learning to real life problems

C3. Write publishable quality papers in machine learning by following:

- Quality standards.
- Structure and content standards.

C4 Peer review and constructively criticize a manuscript in machine learning.

Mandatory activities

- **Attend the class**.
  - Do not rely on the recordings. By attending the class the instructor will get to know you. Active participation will also be beneficial for your mates.
- **Complete the quizzes**. Up to a 10% of the grade.
- **Complete the homework** for each module (Up to 90%).
  - **There will be a rubric** for each homework that will tell you how we grade your work and what are the quality standards that we expect.
  - Two of the homework are journal paper type works. Please attend the corresponding session on paper writing and follow the rubric.
- You can **use the discussion boards**:
  - Interact with your mates, your TA and your instructor.
  - Drop any question or concern for public discussion.

Introduction to the course

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The course is divided into the following modules:

Mod. 2 Introduction to statistical learning theory

Mod. 3 Support vector machines for classification

Mod. 4 Writing a machine learning paper: an introduction

Mod. 5 Support vector machines for regression and novelty detection

Mod. 6 Machine learning in reproducing kernel Hilbert spaces

Mod. 7 Introduction to Gaussian processes for machine learning

Mod. 8 Gaussian processes in a feature (kernel) space

Mod. 9 Gaussian processes for classification

Mod. 10 Adaptive basis funcion models

Course activities

- All modules have quizzes, that will help the students to self assess whether they have properly followed the lessons.
- Most of the modules have programming assignments: students will need to develop different machine learning algorithms.
- In Modules 4 and 8 students will need to write a paper on Support Vector Machines and on Gaussian processes for Regression.

Required knowledge: Students must have knowledge in basic algebra and probability theory. Also, fundamentals of programming in Matlab or Python.
Please read the syllabus for details about the grading of this class

Introduction to statistical learning theory

This module introduces the basics that students need to understand before we go deeper inside in machine learning. We also review the fundamentals of Statistical Learning Theory, which are the foundations of the criteria used to construct learning machines. We provide examples of classification problems.

Support Vector Machines for classification

Once we established the basics of SLT, we use the theory to construct the criterion that is applied in order to optimize linear classification machines. These are called Support Vector Machines for classification (SVC).

Writing a Machine Learning paper

Here we review the main parts of a research paper and hints and procedures that will help you to develop your paper faster in a logical way. We will actually write a paper with the results of previous homework.

Support Vector Machines for regression and novelty detection

In this module we review the concept of regression, and we apply the criterion of the SVM to construct a linear regression algorithm (SVR). We also see nonsuperivsed approaches.

Machine learning in Reproducing Kernel Hilbert Spaces

Previous machines are linear. We need to extend the concept of SVM to nonlinear machines, but keeping the simplicity of liner ones and the criteria used to opimize them. We will use the Kernel trick.

Introduction to linear Gaussian Processes for Machine Learning

The Gaussian Process approach is a different way of constructing a learning machine, that uses the Bayes theorem and a probabilistic model for the data. In this module we review the linear versions of GP models.

Gaussian Processes in a feature (Kernel) space

Here we extend the concept of Gaussian Processes to nonlinear using the Kernel trick. We also learn how to optimize the model parameters using a probabilistic approach

Gaussian Processes for regression

Another important extension of the concept of Gaussian

Processes that is also naturally nonlinear through the use of kernels is its use in classification. In this module we will learn the fundamentals of the GP use for classification. where the probabilistic criterion is preserved and where a probabilistic model of the output is also constructed.

Adaptive basis function models

This last module reviews other Bayesian approaches that are widely used in machine learning. They are the regression and classification trees, random forests and boosting algorithms, which c an be also interpreted as a maximum marging algorithm.

Summary

- This class is an introduction to machine learning that includes SVM, Kernels and GP.
- The intent is that the student
  - Acquire the theoretical knowledge that allows to understand how the machines work.
  - Avoids the use of ML algorithms as black boxes.
  - Learns how to construct actual machines and interpret their results.
  - Learns how to write a successful journal paper.